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## EFFECT OF VARIOUS LEVELS OF NITROGEN AND PHOSPHORUS ON PLANT GROWTH AND CURD YIELD OF CAULIFLOWER (*BRASSICA OLERACEA* L.)

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### ABSTRACT

In order to examine effect of nitrogen and phosphorus levels on the plant growth and curd yield of cauliflower, the trial was laid out in a three replicated randomized complete block design, using six nitrogen and phosphorous (NP) levels. The treatments including T1=Control, T2=50 - 50 kg ha<sup>-1</sup>, T3=75 - 60 kg ha<sup>-1</sup>, T4=100-70 kg ha<sup>-1</sup>, T5=125-80 kg ha<sup>-1</sup>, T6=150-90 kg ha<sup>-1</sup> and T7=175-100 kg ha<sup>-1</sup> were applied in the present study. The results showed that all the growth and yield traits of cauliflower were significantly affected by nitrogen and phosphorus levels. The crop fertilized with highest NP level of 175-100 kg ha<sup>-1</sup> produced 51.16 cm plant height, 44.67 days to harvest, 20.11 cm head diameter, 1.12 kg head weight without folded leaves, 1.33 kg head weight with folded leaves, 26.93 kg yield plot<sup>-1</sup> and 17.95 t ha<sup>-1</sup> curd yield. Similarly, the crop supplied with NP level of 150-90 kg ha<sup>-1</sup> resulted in 49.49 cm plant height, 44.67 days to harvest, 19.45 cm head diameter, 1.10 kg head weight without folded leaves, 1.13 kg head weight with folded leaves, 26.58 kg yield plot<sup>-1</sup> and 17.72 t ha<sup>-1</sup> curd yield. There was a simultaneous decrease in the values of all the growth and yield traits with decreasing NP levels of 125-80 kg ha<sup>-1</sup>, 100-70 kg ha<sup>-1</sup>, 75-60 kg ha<sup>-1</sup> and 50-50 kg ha<sup>-1</sup>. It was concluded that the growth and yield of cauliflower was significantly influenced by varying nitrogen and phosphorus levels; however, the differences in growth and yield traits under NP levels of 150-90 and 175-100 kg ha<sup>-1</sup> were non-significant (P>0.05). Hence, 150-90 kg ha<sup>-1</sup> NP was an optimum level for achieving economically maximum yield performance in cauliflower variety Snowball.

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### INTRODUCTION

Cauliflower (*Brassica oleracea* L.) belongs to the family Cruciferae is an annual plant that reproduces by seed. Typically, only the head (the white curd) of aborted floral meristems is eaten, while the stalk and surrounding thick, green leaves are used in vegetable broth or discarded (Csizinszky, 1996). Its name is from Latin caulis (cabbage) and flower an acknowledgment of its unusual place among a family of food plants which normally produces only leafy

greens for eating (Barbara, 1996). *Brassica oleracea* also includes cabbage, Brussels, though they are of different cultivar groups. Cauliflower can be roasted, boiled, fried, steamed or eaten raw. Steaming or microwaving better preserves anticancer compounds than boiling. The leaves are also edible, but are most often discarded (Stephens, 1998). Cauliflower is low in fat but high in dietary fiber, folate, water, vitamin-C and possessing a high nutritional density (Kirsh et al., 2007). Cauliflower contains several phytochemicals, common in the cabbage family that may be beneficial to human health (USDA, 2011). The nitrogen and phosphorus (NP) are essentially required nutrients for plant growth and fruit development and their recommendation for cauliflower may differ with the soil type and availability of

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these essential nutrients in the soil (Giri *et al.*, 2013). The positive effect of NP on the growth and curd yield of cauliflower is well documented. Yadav and Paliwal (1990) reported that curd yield generally increased with increasing rate of N application and the average yield at 200 kg N ha<sup>-1</sup> was 11.7 kg plot<sup>-1</sup> compared with 3.4 kg plot<sup>-1</sup> at 0 kg N ha<sup>-1</sup>. However, the yield was not significantly affected by the rate of P<sub>2</sub>O<sub>5</sub> application. Bozkurt *et al.* (2011) reported that application of N at the rate of 225 kg ha<sup>-1</sup> and P at the rate of 80 kg ha<sup>-1</sup> showed significant effect on the growth and yield related traits. Jana and Mukhopadhyay (2001) suggested 150 kg N ha<sup>-1</sup> and 120 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> for achieving increased plant height, leaf length, number of leaves per plant, net curd weight and marketable curd yield as compared to lower levels in cauliflowers. Hnojienia *et al.* (2013) applied 250 kg N ha<sup>-1</sup> and 60 kg P ha<sup>-1</sup> and obtained significant increase in the growth and yield of cauliflower over lower nitrogen and phosphorus levels. Camargo *et al.* (2009) reported that N application at 200 kg/ha resulted in the highest average curd size, weight and yield. The rate of P application had no significant effect on yield, although the best results were obtained with the highest rate. Das *et al.* (2000) found that curd yields were highest with N at 294 kg ha<sup>-1</sup>. Kajod *et al.* (2005) found that maximum net returns were obtained with 120 kg N ha<sup>-1</sup> in cauliflower. Katiyar *et al.* (2012) concluded that most of the characters and optimum head yield of cauliflower were favoured by applying 90 kg nitrogen and 90 kg phosphorus per hectare. Keeping in view the importance of NP on growth and curd yield of cauliflower, the present research was conducted to investigate the effect of NP fertilizers on plant growth and curd yield of cauliflower.

## MATERIALS AND METHODS

The present research was conducted to investigate the effect of NP fertilizers on plant growth and curd yield of cauliflower. The experiment was laid out at the experimental area in the orchard, Department of Horticulture, Sindh Agriculture University Tandojam during 2014 in a three replicated Randomized Complete Block Design (RCBD). Cauliflower variety (Snowball) was planted in a plot size of 5m x 3m. The land was prepared by giving 2 dry plowings followed by land levelling. The seven different nitrogen and phosphorus levels viz; Control (0-0 kg ha<sup>-1</sup>, 50 - 50 kg ha<sup>-1</sup>, 75 - 60 kg ha<sup>-1</sup>, 100-70 kg ha<sup>-1</sup>, 125-80 kg ha<sup>-1</sup>, 150-90 kg ha<sup>-1</sup>, 175-100 kg ha<sup>-1</sup>) were tested. All P along with 1/3<sup>rd</sup> of N were applied at the time of sowing by mixing in the soil, while the remaining N was applied in two equal split doses; first after one month of sowing and second split at one month interval. The observations were recorded on the parameters that included plant height (cm), Number of days taken to harvest, Head diameter (cm), Head weight with folded leaves (kg), Head weight without folded leaves (kg), and Yield plot<sup>-1</sup> (kg) and yield ha<sup>-1</sup> (tons).

### Observations recording procedure

- **Plant height (cm):** Plant height was recorded by measuring tape in centimeters from bottom to top of the leaves in randomly selected five plants in each plot and averages were worked out.
- **Head diameter (cm):** The head diameter was recorded in centimeters in randomly selected five plants in each plot by cutting the head right in the center and measured by measuring tape and average was calculated.

- **Head weight with folded leaves (kg):** The head weight along with the folded leaves was taken in kilograms by electrical balance.
- **Head weight without folded leaves (kg):** The head weight without the folded leaves was also taken by electrical balance in kilograms on the basis of randomly selected plants in each plot and averages were worked out.
- **Number of days taken to harvest:** The number of days from sowing till the date of harvesting of head was recorded in each plot and average was calculated.
- **Yield (t ha-1):** The yield ha-1 was recorded in kilograms and then converted into tons on the basis of following formula:

$$\text{Yield ha}^{-1} = \frac{\text{Yield plot}^{-1}}{\text{Plot size (m}^2\text{)}} \times 10000$$

### Statistical Analysis

The data thus obtained were subjected to statistical analysis using a Statistical computer package (Gomez and Gomez, 1984) to derive analysis of variance. The least significant different (LSD) test was applied to compare treatment superiority in case results were significant at 0.05 probability level.

## RESULTS

### Plant height (cm)

The plant height as influenced by various nitrogen and phosphorus levels was determined from each replication on the basis of randomly selected five cauliflower plants and the results are presented in Table 1. The analysis of variance exhibited significant ( $P < 0.05$ ) effect of nitrogen and phosphorus (NP) levels on the plant height of cauliflower. The cauliflower plants attained maximum height (51.16 cm) when received nitrogen and phosphorus at the rate of 175-100 kg ha<sup>-1</sup>, closely followed by 49.49 cm plant height in plots receiving nitrogen and phosphorus at the rate of 150-90 kg ha<sup>-1</sup>. A simultaneous reduction in height of the cauliflower plants i.e. 46.22, 43.52, 38.77 and 36.84 cm was recorded in plots receiving nitrogen and phosphorus at the rates of 125-80, 100-70, 75-60 and 50-50 kg ha<sup>-1</sup>, respectively. However, the shortest plants (29.21 cm) were recorded in control plots, where nitrogen and phosphorus were not applied. Due to application of nitrogen and phosphorus at higher rates, the crop growth was stimulated and hence plants grew taller with each increased level of these fertilizers. However, this increase in plant height under nitrogen and phosphorus level of 175-100 kg ha<sup>-1</sup> was not so pronounced ( $P > 0.05$ ) when compared with the plant height under nitrogen and phosphorus level of 150-90 kg ha<sup>-1</sup>.

### Days taken to harvest

The days taken to harvest of cauliflower as affected by different nitrogen and phosphorus levels were recorded in all the plots and the data are given in Table 1. The analysis of variance suggested significant ( $P < 0.05$ ) impact of nitrogen and phosphorus application on the number of days taken to harvest of cauliflower heads. The cauliflower took minimum days to harvest (44.67) when given nitrogen and phosphorus at the higher rates of 150-90 and 175-100 kg ha<sup>-1</sup>, closely followed

**Table 1. Effect of nitrogen and phosphorous on the plant height, days taken to harvest, head diameter of cauliflower**

N-P levels	Plant Height (cm)	Days taken to harvest	Head Diameter (cm)
T1=0-0 kg ha <sup>-1</sup>	29.21 D	48.00 A	11.58 E
T2 =50-50 kg ha <sup>-1</sup>	36.84 C	45.67 B	13.15 D
T3 =75-60 kg ha <sup>-1</sup>	38.77 C	45.33 B	14.41 D
T4 =100-70 kg ha <sup>-1</sup>	43.52 B	45.00 B	16.67 C
T5 =125-80 kg ha <sup>-1</sup>	46.22 B	45.33 B	18.12 B
T6= 150-90 kg ha <sup>-1</sup>	49.49 A	44.67 B	19.45 A
T7=175-100 kg ha <sup>-1</sup>	51.16 A	44.67 B	20.11 A
S.E.±	1.2457	0.5245	0.5922
LSD 0.05	2.7142	1.1429	1.2903

In a column, means followed by same letters are not significantly different at P=0.05 as suggested by LSD test.

**Table 2. Effect of nitrogen and phosphorous on head weight without folded leaves, head weight with folded leaves, yield plot<sup>-1</sup> and yield ha<sup>-1</sup> of cauliflower**

N-P levels	Head weight without folded leaves (kg)	Head weight with folded leaves (kg)	Yield plot <sup>-1</sup> (kg)	Yield ha <sup>-1</sup> (tons)
T1=0-0 kg ha <sup>-1</sup>	0.28 F	0.34 E	4.73 F	3.16 F
T2 =50-50 kg ha <sup>-1</sup>	0.55 E	0.65 D	13.10 E	8.73 E
T3 =75-60 kg ha <sup>-1</sup>	0.65 D	0.85 C	15.50 D	10.34 D
T4 =100-70 kg ha <sup>-1</sup>	0.72 C	0.86 C	17.35 C	11.57 C
T5 =125-80 kg ha <sup>-1</sup>	0.96 B	1.14 B	23.00 B	15.33 B
T6= 150-90 kg ha <sup>-1</sup>	1.10 A	1.31 A	26.58 A	17.72 A
T7=175-100 kg ha <sup>-1</sup>	1.12 A	1.33 A	26.93 A	17.95 A
S.E.±	0.0302	0.0396	0.6379	0.4253
LSD 0.05	0.0659	0.0862	1.3900	0.9266

In a column, means followed by same letters are not significantly different at P=0.05 as suggested by LSD test.

by 45.33, 45.00, 45.33 and 45.67 days to harvest recorded in plots given nitrogen and phosphorus fertilizers at the rates of 125-80, 100-70, 75-60 and 50-50 kg ha<sup>-1</sup>, respectively. However, the maximum days to harvest (48.00) were recorded in control plots where the crop was left untreated. It was observed that with the application of nitrogen and phosphorus fertilizers, the cauliflower heads became harvestable earlier than those of unfertilized plots. The least significant difference test (LSD) test suggested that differences in days taken to harvest between nitrogen and phosphorus levels of 175-100, 150-90, 125-80, 100-70, 75-60 and 50-50 kg ha<sup>-1</sup> were insignificant (P>0.05) and significant (P<0.05) when compared with control.

#### Head diameter (cm)

The diameter of the cauliflower head as affected by different nitrogen and phosphorus levels was measured in all the plots and the results are given in Table 1. The analysis of variance demonstrated significant (P<0.05) impact of nitrogen and phosphorus levels on the diameter of head in cauliflower. The cauliflower plants produced head of maximum diameter (20.11 cm) when given nitrogen and phosphorus at the rate of 175-100 kg ha<sup>-1</sup>, closely followed by 19.45 cm diameter of head observed in crop receiving nitrogen and phosphorus at the rate of 150-90 kg ha<sup>-1</sup>.

There was a successive decrease in diameter of cauliflower head i.e. 18.12, 16.67, 14.41 and 13.15 cm with decrease in nitrogen and phosphorus up to 125-80, 100-70, 75-60 and 50-50 kg ha<sup>-1</sup>, respectively. However, the cauliflower head diameter was minimum (11.58 cm) in plots kept untreated (control) where nitrogen and phosphorous were not applied. A linear reduction in head diameter was recorded with each decreased level of nitrogen and phosphorus. The LSD test suggested that differences in head diameter between nitrogen and phosphorus levels of 175-100 kg ha<sup>-1</sup> and 150-90 kg ha<sup>-1</sup> were insignificant (P>0.05) and significant (P<0.05) when compared with rest of the treatments.

#### Weight of head without folded leaves (kg)

The weight of cauliflower head without folded leaves as affected by different nitrogen and phosphorus levels was weighed and the results are shown in Table 2. The analysis of variance depicted significant (P<0.05) effect of varying nitrogen and phosphorus levels on the weight of cauliflower head without folded leaves. The cauliflower plants produced head with maximum weight without folded leaves (1.12 kg) when fertilized with nitrogen and phosphorus level of 175-100 kg ha<sup>-1</sup>, closely followed by 1.10 kg weight of head without folded leaves, recorded in crop receiving nitrogen and phosphorus at the rate of 150-90 kg ha<sup>-1</sup>. The weight of cauliflower head declined as 0.96, 0.72, 0.65 and 0.55 kg with reduction in nitrogen and phosphorus as 125-80, 100-70, 75-60 and 50-50 kg ha<sup>-1</sup>, respectively. However, the weight of head without folded leaves in cauliflower was lowest (0.28 kg) in plots kept untreated of nitrogen and phosphorus (Control). It was observed that the weight of head without folded leaves increased successively with each increment in nitrogen and phosphorus levels and this trend was mainly associated with the plant height and head diameter. The LSD test envisaged that differences in weight of head without folded leaves between nitrogen and phosphorus levels of 175-100 kg ha<sup>-1</sup> and 150-90 kg ha<sup>-1</sup> were non-significant (P>0.05) and significant (P<0.05) when compared with other treatments.

#### Weight of head with folded leaves (kg)

The cauliflower crop was examined for its head with folded leaves to assess its response to various nitrogen and phosphorus levels and the data are reported in Table 2. The analysis of variance represented significant (P<0.05) effect of different nitrogen and phosphorus levels on the weight of cauliflower head with folded leaves. It is evident from the results that the heads with folded leaves weighted maximum (1.33 kg) when fertilized with nitrogen and phosphorus level of 175-100 kg ha<sup>-1</sup>, closely followed by 1.31 kg when nitrogen and phosphorus was applied at the rate of 150-90 kg ha<sup>-1</sup>.

The weight of cauliflower head with folded leaves diminished with decreasing fertility levels and it was 1.14, 0.86, 0.85 and 0.65 kg under nitrogen and phosphorus levels of 125-80, 100-70, 75-60 and 50-50 kg ha<sup>-1</sup>, respectively. However, the lowest weight of head with folded leaves (0.34 kg) was noted in control plots, where no fertilizer was applied. It was observed that the weight of head with folded leaves consecutively improved with increasing nitrogen and phosphorus levels which was mainly influenced by the plant height, head diameter and weight of head without folded leaves. The LSD test suggested that differences in weight of head with folded leaves between nitrogen and phosphorus levels of 175-100 kg ha<sup>-1</sup> and 150-90 kg ha<sup>-1</sup> were insignificant ( $P>0.05$ ) and significant ( $P<0.05$ ) when compared with remaining treatments.

#### Yield plot<sup>-1</sup> (kg)

The yield plot<sup>-1</sup> as influenced by various nitrogen and phosphorus levels was recorded in all the treatments and the results are presented in Table 2. The analysis of variance exhibited significant ( $P<0.05$ ) effect of nitrogen and phosphorus levels on the cauliflower yield plot<sup>-1</sup>. The highest cauliflower yield (26.93 kg plot<sup>-1</sup>) was achieved when the crop received nitrogen and phosphorus at the rate of 175-100 kg ha<sup>-1</sup>, closely followed by yield of 26.58 kg plot<sup>-1</sup> in crop receiving nitrogen and phosphorus at the rate of 150-90 kg ha<sup>-1</sup>. A simultaneous reduction in cauliflower yield was noted which was 23.00, 17.35, 15.50 and 13.10 kg ha<sup>-1</sup> when the crop was given nitrogen and phosphorus at the rates of 125-80, 100-70, 75-60 and 50-50 kg ha<sup>-1</sup>, respectively. However, the minimum yield (4.73 kg plot<sup>-1</sup>) was recorded in control plots, where nitrogen and phosphorus were not applied. Due to application of nitrogen and phosphorus at higher rates, the crop traits such as plant height, head diameter, weight of head without folded leaves and weight of head with folded leaves improved substantially and these traits linearly influenced the yield plot<sup>-1</sup> in positive direction. However, this increase in yield plot<sup>-1</sup> under nitrogen and phosphorus level of 175-100 kg ha<sup>-1</sup> was not so pronounced ( $P>0.05$ ) when compared with the yield plot<sup>-1</sup> under nitrogen and phosphorus level of 150-90 kg ha<sup>-1</sup>.

#### Yield ha<sup>-1</sup> (tons)

The yield ha<sup>-1</sup> was calculated on the basis of yield plot<sup>-1</sup> and the data are shown in Table 2. The analysis of variance illustrated significant ( $P<0.05$ ) effect of nitrogen and phosphorus levels on cauliflower yield ha<sup>-1</sup>. The highest cauliflower yield (17.95 t ha<sup>-1</sup>) was recorded from the plots given nitrogen and phosphorus at the rate of 175-100 kg ha<sup>-1</sup>, closely followed by yield of 17.72 t ha<sup>-1</sup> in crop receiving nitrogen and phosphorus at the rate of 150-90 kg ha<sup>-1</sup>. The cauliflower yield was decreased to 15.33, 11.57, 10.34 and 8.73 t ha<sup>-1</sup> when the crop fertilized with nitrogen and phosphorus at the rates of 125-80, 100-70, 75-60 and 50-50 kg ha<sup>-1</sup>, respectively. However, the lowest yield (3.16 t ha<sup>-1</sup>) was noted in control plots, where nitrogen and phosphorus were not applied. Due to application of nitrogen and phosphorus at higher rates, the crop parameters plant height, head diameter, weight of head without folded leaves, weight of head with folded leaves and yield plot<sup>-1</sup> improved considerably and these traits contributed to higher yield ha<sup>-1</sup>. However, this increase in yield ha<sup>-1</sup> under nitrogen and phosphorus level of 175-100 kg ha<sup>-1</sup> was not economical ( $P>0.05$ ) when compared with the yield ha<sup>-1</sup> under nitrogen and phosphorus level of 150-90 kg ha<sup>-1</sup>.

## DISCUSSION

Nitrogen and phosphorus are key elements and their availability in the soil in adequate quantities ensures the proper plant growth for achieving desired crop yields (Thompson *et al.*, 2000). The present study was carried out to examine the effect of nitrogen and phosphorus levels on the plant growth and curd yield of cauliflower. The study showed that growth and yield traits of cauliflower were significantly affected by nitrogen and phosphorus levels. The crop fertilized with highest nitrogen and phosphorus levels showed significantly higher values for all the investigated growth and yield related traits. Better performance of the crop for all the investigated traits might have been associated with the application of nitrogen and phosphorus levels in large quantity that significantly enhanced both the fertility and productivity of the soil resultantly plant grew taller with maximum height and head size. These results are further supported by Giri *et al.* (2013) who reported that in soils with low organic matter and inadequate in available N and P, higher amounts of these elements would be needed to fulfill the crop requirements for proper growth and desired crop harvest. Yadav and Paliwal (1990) reported that curd yield generally increased with increasing rate of N application and the average yield at 200 kg N ha<sup>-1</sup> was 11.7 kg plot<sup>-1</sup> compared with 3.4 kg plot<sup>-1</sup> at 0 kg N ha<sup>-1</sup>. However, the yield was not significantly affected by the rate of P<sub>2</sub>O<sub>5</sub> application. Bozkurt *et al.* (2011) reported that application of N at the rate of 225 kg ha<sup>-1</sup> and P at the rate of 80 kg ha<sup>-1</sup> showed better growth and development of plants. Jana and Mukhopadhyay (2001) suggested 150 kg N ha<sup>-1</sup> and 120 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> for achieving increased plant height, leaf length, number of leaves per plant, net curd weight and marketable curd yield. Hnojienia *et al.* (2013) applied 250 kg N ha<sup>-1</sup> and 60 kg P ha<sup>-1</sup> and obtained significant increase in the growth and yield of cauliflower. Sharma and Rastogi (1992) reported that greatest plant height, number of branches/plant, seed yield/plant and yield/ha were obtained at 200 kg N/ha in cauliflower. Singh and Naik (1993) reported that N application at 200 kg/ha resulted in the highest average curd size, weight and yield.

Jana and Mukhopadhyay (2001) concluded that successive increase in nitrogen levels up to 150 kg N ha<sup>-1</sup> increased plant height, leaf length, leaf width, days to curd initiation, days to curd maturity, curd diameter, curd depth, net curd weight and marketable curd yield. Kajod *et al.* (2005) found that maximum net returns were obtained with 120 kg N ha<sup>-1</sup> in cauliflower. Camargo *et al.* (2009) determined that the nitrogen rates increased linearly in leaves and curds when higher levels of N were applied through soil. Katiyar *et al.* (2012) concluded that most of the characters and optimum head yield of cauliflower were favoured by applying 90 kg nitrogen and 90 kg phosphorus per hectare. The present research and findings reported from the past researches suggested great variation in nitrogen and phosphorus requirements for cauliflower production and these variations might be associated with the fertility status of the soil and varieties used by different researcher in different parts of the world.

## Conclusion

It was concluded that the growth and yield of cauliflower was significantly influenced by varying nitrogen and phosphorus levels; however, the differences in growth and yield traits under N-P levels of 150-90 and 175-100 kg ha<sup>-1</sup> were non-significant ( $P>0.05$ ).

Hence, 190-90 kg ha<sup>-1</sup> N-P was an optimum level for achieving economically maximum yield performance in cauliflower variety Snowball.

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